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EDITORIAL.

SHOT-HOLE BORER

In the last issue of *The Tea Quarterly* (pages 28-34) a report was given of the discussion on Shot-hole borer which took place at the Sub-Conference held at St. Coombs in March.

It is apparent that there is some divergence of opinion between different districts in regard to the seriousness of this pest and the extent of the loss in crop resulting from attack. Representatives from Uva, Kotmale, Kalutara and the Southern Province, particularly those from Uva, considered that the pest was on the increase and Uva delegates attributed a steady increase in wood rot and deterioration of bushes to its presence. Opinion in Dimbula was on the whole that attacks are now less severe and representatives from the Ratnapura area evidently regarded the pest much less seriously and were inclined to support the view taken in the Annual Report of the Planters' Association of Ceylon for 1939, page 74, where it is stated: "Shot-hole borer would not appear to be an economic factor under the present standard of cultivation." This comment of course was made in reference to the low-country. One or two speakers also confirmed the impression gained by the Institute that, speaking generally, shot-hole borer is not very greatly in evidence on small-holdings.

It is not easy to reconcile the above conflicting opinions. Varying climatic factors cannot be the sole explanation, for while one might expect the effects of infestation to be more evident in a district such as Uva with considerable dry periods, than in, say, Ratnapura, this would not account for the difference between the latter area and, say, Kalutara. It might be suggested that the position would be influenced by variations in the general level of cultivation in different districts. Whether wide fluctuations of this type, after

making allowances for the general level of cropping, really exist or not is a matter for enquiry, but the position on small-holdings indicates that a relatively low incidence of shot-hole borer can exist side by side with a very low level of cultivation.

In regard to the question of spread of shot-hole borer to new areas, one can only say that the number of estates previously free and now reporting infestation is exceedingly small. This does not, of course, mean that the *intensity* of attack may not be greater than formerly on estates already infected. Should, however, this be the case, the position should be reflected in crop yields and a careful analysis of a sufficient number of estate records would throw light on this point. It must be remarked, however, that considerable care will have to be taken in compiling such statistics to allow for variations in cultivation programmes during the depression and the effect of restriction in recent years, and it may not, in fact, be at all easy to obtain figures by which present yields can be accurately compared with those of previous years.

Crop figures alone will not, however, suffice in estimating the economic results of infestation. Even if the intensity of infection be increasing, former yields may have been maintained by a higher level of manuring leading to a higher cost of production. Again, if it indeed be the fact that wood rot is increasing on infested estates, the potential loss in capital value must be taken into account.

From the above considerations it is clear that there is considerable need for more reliable data on the whole question so that the status of the pest at the present time can be more accurately assessed. It is hoped, therefore, to make arrangements for the collection of such information.

With regard to practical measures against shot-hole borer, the position is one of much difficulty. The earlier work of Jepson and others, which is fully confirmed by investigations on similar lines carried out by the Institute, show clearly that while a liberal manurial programme accelerates the healing of shot-hole galleries, thereby reducing breakage of branches and loss of crop, such treatment does nothing to reduce the incidence of attack. Measures directed against the beetle are difficult to devise since the latter spends its active life *inside* the wood of the infected bush. It is thereby largely protected against sprays or dusts or from attack by predators or parasites. In regard to the latter it was suggested at the Sub-Conference that the relative freedom of Java tea from attack by shot-hole borer was due to biological control of the pest, and the Institute was urged to send immediately an officer to Java to search for the parasite responsible. If there were reason to think that this opinion represented the true facts, measures on the lines proposed would already

have been taken by the Institute. Unfortunately, as was pointed out at the Conference, there is no evidence to show that such biological control exists and this view of the position in Java has been confirmed by later information received from the Director of the Proefstation, West Java. It does not appear, therefore, that any very useful purpose would at present be served by sending an officer to that country. Enquiries are proceeding in regard to the position in South India where shot-hole borer also causes little damage, and information concerning the relationship of certain mites to *Xyleborus* is being sought from America. The outlook is not promising, however; of the very large number of different species of *Xyleborus*, very few indeed are known to have parasites and the prospect of finding anything that will successfully deal with our own species is somewhat remote.

The Institute will of course do everything in its power to obtain further information on this aspect of the question as, outside biological control, there would appear to be little hope of elminating the pest.

ROLAND V. NORRIS

'BITTEN-OFF' DISEASE OF TEA SEEDLINGS.

C. H. GADD, D.Sc.

Petch [6] described under the name 'Bitten off' root disease, a disease of tea seedlings which is characterised by the disappearance of the finer rootlets of pulled plants as though they had been bitten off by insects, though insects suspected of causing the injury are not usually found. He pointed out that if the plants are carefully dug out, the roots are found to be decaying, the decay beginning at the ends of the finer rootlets.

'Bitten off' is one of the most destructive diseases of certain tea nurseries in Ceylon. The first indication that anything is wrong is the unthrifty appearance of the plants; the leaves are crowded together and the older leaves fall prematurely. Eventually growth ceases entirely; the leaves fall and the plants die. It is usually the unsatisfactory growth of the seedlings which draws attention to the disease. By that time, not only have the finer roots disappeared but the greater part of the tap root also (Fig. 1). Frequently, no trace of the decayed roots can be found, but the remains of the tap root and the stumps of the laterals show signs of decay.

Petch also suggested that a species of Rhizoctonia was the cause of the disease. The isolation from the roots of diseased specimens of a large number of fungi, including a species of Rhizoctonia, and their later transference to roots of healthy seedlings failed, in every instance, to cause the disease. As the extensive search for a possible parasite failed to disclose one which would attack seedling roots when growing under normal healthy conditions, attention was given to possible environmental causes.

Bernard in the Dutch East Indies has described a somewhat similar disease of tea seedlings in which the primary root turned brown and rotted off from the tip upwards soon after it had emerged from the seed. The cause of this disease was attributed to excessive dampness in the seed bed at the time of germination, which weakened the young plants and favoured the development of a parasite.

It is to be expected that excess of water alone, without the intervention of a parasite, will lead to the death of tea seedlings, if such conditions are maintained, but the symptoms preceding such deaths have not been described. To ascertain what these might be the following experiment was devised.

Fig. 1. Seedlings showing 'Bitten off' symptoms.

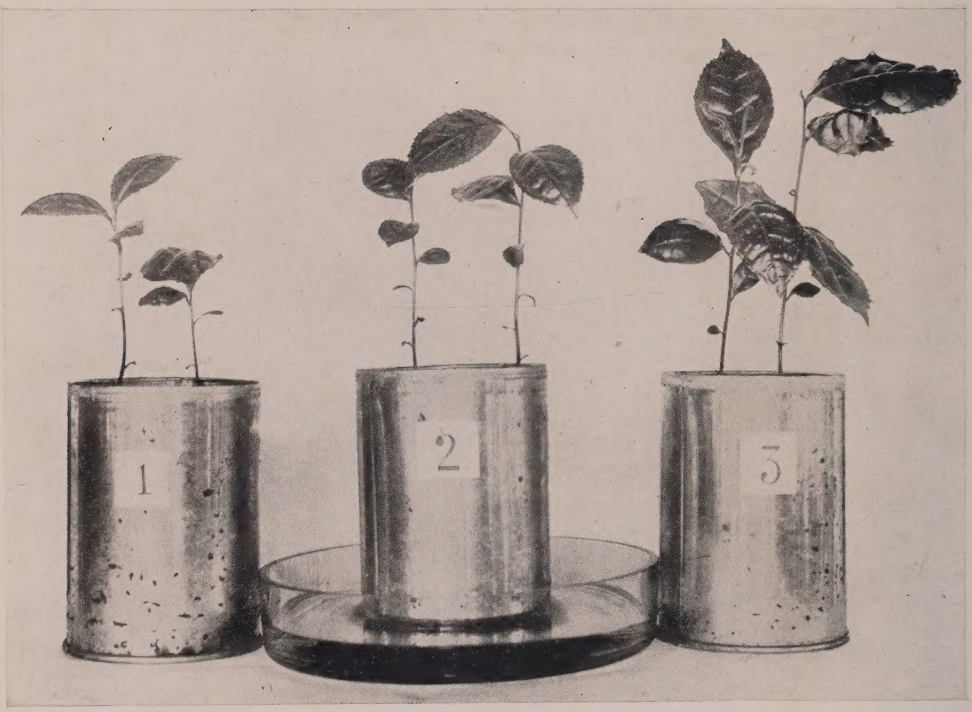

Fig. 2. Seedlings grown under different soil moisture conditions.

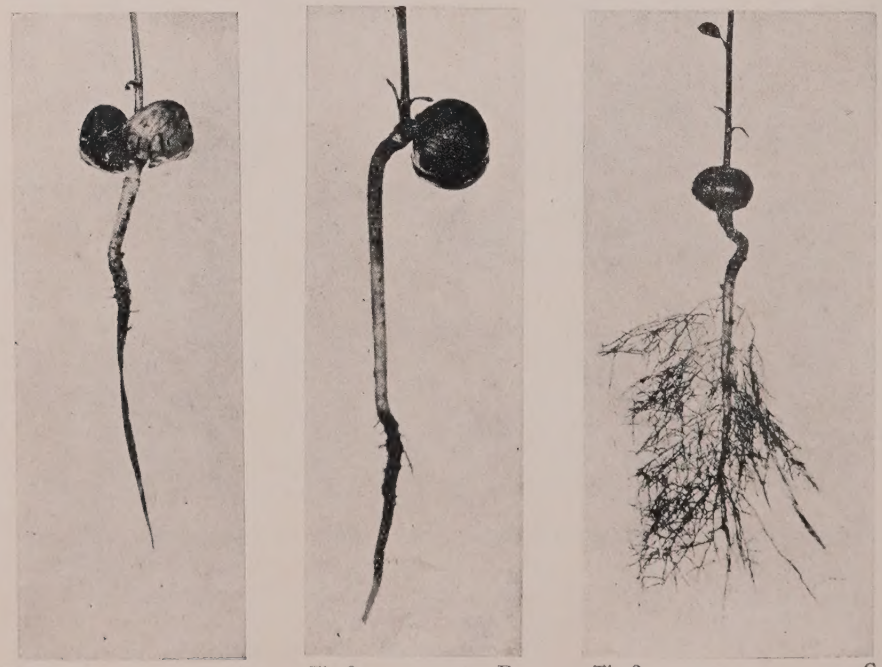

Fig. 3. Roots from tins 1. 2 and 3 are shown as A, B and C respectively.

A black Nuwara Eliya soil was first tested for its water-holding capacity. Known weights of the dry soil were placed in tins with perforated bottoms and then saturated with water. The excess of water was allowed to drain away and when drip had ceased from the bottom of the tin the soil was reweighed. The condition of the soil then was such that it carried the maximum amount of water without being actually water-logged. The mean of 3 tests gave a value for the water content as 49 per cent of the weight of the dry soil. From this result it was decided to add 44 per cent of water to that soil (*i.e.*, 5 per cent less than the maximum) to represent a very wet but not water-logged soil.

Young tea seedlings, selected for uniformity of size, were planted in similar soil in cylindrical tins 8.5 cms. in diameter and 12 cms. deep, the bottoms of which were perforated to allow of drainage. Water was allowed to drip continuously from a fine tube on to tin No. 1 and to drain away from the bottom of the tin. The rate of drip was at first equivalent to a rainfall of 4 inches per day but later it was reduced to an equivalent of $1\frac{1}{2}$ inches per day. These conditions represented continuous, though abnormal, rainfall with fairly good drainage.

The second tin, No. 2, was placed in a shallow basin containing water sufficient to cover the bottom of the tin to a depth of 1 cm. No water was applied to the surface of the soil. This represented a water-logged soil with a water table about 11 cms. or 4 inches below the soil level.

To the third tin, water was added until the water content amounted to 44 per cent of the dry weight of the soil. Periodically, water was added to restore the water content. This represented a wet but not water-logged soil.

After 3 months the experiment was stopped. The condition of the plants at the end of the experiment is shown in Figure 2. The plants in tin No. 3 had made fair growth, while those in tins 1 and 2 had become unthrifty but showed no signs of organic disease. When however, the plants were carefully removed from the soil their roots presented another picture (Fig. 3). The roots of the plants in tin No. 3 were well developed with no signs of decay, but the roots of the plants from tins 1 and 2 were in poor condition. There were no lateral roots and the main root had decayed for some distance from the tip towards the base. In short, these plants exhibited the symptoms of 'Bitten off.'

There was nothing to choose between the root systems in tins Nos. 1 and 2. There were no fine roots in the upper and supposedly drier layers of tin No. 2 and it was evident that an excess of running

water was as detrimental as an excess of stagnant water brought about by an artificial water table.

Here then was a possible cause of the 'Bitten off' disease of tea seedlings, but field examinations soon demonstrated that an excess of water was not the sole cause. A few cases of the disease have been investigated where it was possible to demonstrate that an excess of water was the cause, but for every such case many were encountered for which such an explanation was very unsatisfactory.

Petch was the first to point out that 'Bitten off' occurred most frequently in nurseries made on the sites of old buildings and labourers' gardens. Enquiries regarding the previous history of affected gardens fully confirmed Petch's observation. Excess of water as a cause does not account satisfactorily for these observations, so other possible causes had to be sought for.

In order to ascertain the effect of acidity on the development of the tea plant, seedlings were grown in water culture solutions of various pH values.[4] These experiments indicated that pathological symptoms, as shown by the death of roots and yellowing and dwarfing of leaves, can be induced with solutions approximately neutral in reaction, and corrected when the acidity of the solution is increased. Confirmation was obtained from pot experiments [5] which also demonstrated that the optimum pH value of soil for tea lies between 5.3 and 6.5 and that higher values lead to the development of pathological symptoms. In short, tea will not tolerate a neutral or alkaline soil and such conditions give rise to the disease known as 'Bitten off.'

These conclusions have been amply confirmed by numerous analyses made by the Agricultural Chemist, a few of which have been published.[1] They also offer a satisfactory explanation of why 'Bitten off' so frequently occurs in nurseries formed on old building sites. The alkalinity on such sites results from the incorporation into the soil of mortar and lime rubble. The reason why line gardens prove so unsatisfactory is perhaps not so apparent until the fact is taken into consideration that labourers use as manure wood ashes which are highly alkaline.

Alkalinity of soil can be brought about by means other than liming. The excessive use in gardens of wood ashes from domestic fires, and in tea adjoining factories of ashes from the driers, is a common cause of detriment to soils used for tea culture.

The effect of wood ashes was clearly demonstrated in a nursery visited recently. The site adjoined the factory and was separated from it by a broad path. The tea plants in the nursery were healthy except for those growing along a strip parallel with the path.

Enquiries elicited the information that at one time there had been a long flower bed alongside the path, and at intervals a liberal supply of wood ashes had been applied to it with beneficial results to the flowers. When the land was used as a tea nursery the exact position of the bed could be recognised by the presence of seedlings affected by 'Bitten off' disease in that area, whereas the plants in the remainder of the nursery were healthy.

Eden has also called attention to the detrimental effect of compost when applied in undue amounts in supply holes, nurseries and supply baskets.[3] Well made compost is usually alkaline and unless suitably diluted with acid soil the resulting mixture is insufficiently acid for healthy growth of tea.

Judging from the number of plants affected by 'Bitten off' sent to the laboratories each year, it is evident that the cause of the trouble is still not generally recognised. Tea will not tolerate anything but acid soil, and land which has a neutral or alkaline reaction, though excellent for most other plants, is quite unsuited for tea. There are two ways of determining whether a particular soil is suitable for tea culture. One is by attempting to grow tea on it and the other is by having its reaction tested. The latter method is quicker and far cheaper. Many soil reaction tests are made after trouble has occurred, and, though these have supplied a mass of evidence regarding cause and effect, it would be more satisfactory to all concerned if the tests were made before risking failure. Much loss could then be avoided.

Although 'Bitten off' is best known as a disease of seedlings, it will be realised from the nature of its cause that it is not restricted to seedlings. Adult tea will exhibit comparable symptoms if the reaction of the soil is changed owing to cultural treatment. One such way of changing the soil reaction has already been mentioned, viz. the excessive use of wood ashes from factory driers. The condition of the tea immediately surrounding a factory will often indicate what use has been made of factory wood ashes.

Liming is a well-known agricultural practice but for obvious reasons it cannot be recommended for tea.

Ceylon soils in the tea areas are usually acid. Small areas may have had the reaction altered by means already mentioned, but Eden has also called attention to large-scale occurrence of soil alkalinity,[2] and instances a whole estate found to be suffering from pronounced soil alkalinity. Such areas are likely to occur in the vicinity of limestone. Attempts to establish well-grown seedlings or tea stumps in such areas are likely to fail.

SUMMARY

1. An acid soil is essential for successful tea culture. If the soil is not sufficiently acid, the plants develop symptoms characteristic of the disease termed 'Bitten off.'

2. Old building sites and line gardens are usually unsuitable for nursery sites owing to the soil being alkaline due to lime rubble or wood ashes.

3. Injudicious use of compost will have the same effect.

4. Soils in the vicinity of limestone outcrops are likely to be unsuitable for tea culture owing to their unfavourable reaction.

5. If there is any doubt concerning the suitability of sites for tea nurseries the soil reaction should be tested, preferably before the seed is sown, and not after the disease symptoms have occurred.

6. Another but less common cause of the disease is excessive water.

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SOIL EROSION PREVENTION ON TEA ESTATES*

C. HUNTLEY-WILKINSON

I have been invited to bring up-to-date previous articles appearing in *The Tea Quarterly*, Vol. VI, Part IV, Page 176; Vol. VII, Part I, Page 118; and Vol. X, Part IV, Page 206.

A description will be included of the methods by which an almost complete ground cover was established on two estates in the Dimbula District, resulting after a period of years in increased cropping of the tea with applications of nitrogen which did not exceed 35.3 lb. per acre per annum.

The Report of the Ceylon Soil Erosion Committee was signed on October 1st, 1930. The consensus of opinion of that Committee was that "The first and most important step in the control of the present soil erosion on tea estates is the provision of ground covers."

With regard to other preventative measures, the officers of the Tea Research Institute have designated these as a second line of defence only.

What has prevented a more wholesale adoption of ground covers on tea estates is that the ideal cover has not yet been found. An ideal cover would perhaps be one (a) which is leguminous, (b) does not climb into the plucking surface, (c) does not possess a deep and tenacious root system and (d) can easily be eliminated if required.

I submit, however, that if this ideal be awaited, a further long period will ensue of soil denudation on tea estates. Further I would welcome an official statement from our scientists as to whether a leguminous plant supplies enough additional nitrogen to the soil to make a very great difference.

After a period of some nine years of ground cover establishment on one of the estates previously referred to, the following advantages can now be claimed: A record tea yield in the ninth year with no abnormal or increased applications of nitrogen and soil erosion brought to a minimum.

* The Institute does not necessarily endorse the views expressed by contributors other than members of the Staff.

The cost of upkeep of roads and drains on this property is now estimated at 50 cents per acre, but much of this is not actually spent as it would be unnecessary. The same policy of ground cover establishment was adopted on the other estate a few years later, and last year the yield would undoubtedly have been a record one had not the Directors decided to restrict crop in the last three months of the year. On both estates certain obvious control measures have been rigidly adhered to and these will be mentioned later on in this article.

A Visiting Agent some eight years ago remarked to me: "Why bother about soil erosion on estates such as these where the question is not an acute one ?" I maintain that the question *is* acute on every tea estate in the Ceylon hills. To prove this, one has only to establish a *Paspalum dilatatum* ridge, even on slightly sloping land, and after a period of even a year it will be found that a distinct "step" has been formed, in some cases as much as eight inches in height. The *abuse of the scraper* still continues on clean-weeded estates, and the best Visiting Agents and Superintendents have not, as yet, been able effectively to prevent this. I maintain that the scraper will *never* be effectively controlled and that therefore this dangerous implement should be discontinued.

Then again, one often hears it laid down that tea itself can be a cover to the soil. But can it ? What about the period between pruning and refoliation ? The evils accruing can well be noted from a bird's-eye view of any considerable area of tea when the large proportion of bare eroding land can be appreciated.

I will now endeavour to demonstrate the measures actually adopted on the two estates in question.

CONTOURING

A small two-acre clearing was planted on very steep land where the soil was so gravelly and poor that it had never previously been considered economic to plant anything but gums thereon. This was done in June-July 1929. The tea was planted strictly on the contour at intervals of two feet, the spacing between the lines being one of five feet, resulting in a plant incidence of 4,356 per acre. No holes were cut and no soil was removed; the actual method was to lay a six-foot reaper on the ground with a spirit level thereon, pegs being put in at six-foot intervals. Instead of cutting out a drain along these lines, the earth was merely forked carefully and deeply without removal of soil. In order to counter the fact that the plants were to be put out in a large proportion of sub-soil, artificial manure was sprinkled along the line and carefully mixed with the soil by hand. The result from this method was an entire retention of soil on this

steep land, which was proved by the fact that a watercourse conveying water to the factory and running below the whole length of the clearing was at no time out of commission. As time went on terraces were gradually cut and *Paspalum dilatatum* was planted on the edges.

There are no field drains whatever in this area and only two nettikhans, which are carpeted with Paspalum grass. A five-foot spacing was necessary between the lines in order to give room for cultivation and standing room for pluckers. Where these lines go round a curve in the hill it was found that the spacing increased in places to as much as ten-foot intervals and intermediate lines were established where necessary. These have never led to disputes amongst the pluckers. The bushes are now pruned and plucked at a slope parallel with the slope of the land and tipping is done by laying a rope down the hill as the work is in progress and seeing that the rope is touching the plucking surface down its whole length.

Plucking was commenced in June, 1934 and the following yields have been recorded:—

1934	297	lbs. per acre
1935	672	,, ,, ,,
1936	368	,, ,, ,,
1937	1,138	,, ,, ,,
1938	938	,, ,, ,,
	(Travancored in September)	
1939	932	lbs. per acre

I have come to the conclusion now that even if terraces are not deliberately established, if tea is planted strictly on the contour at a spacing of three feet, natural terraces will form and the soil will not break away between the bushes. This would have reduced the plant incidence from 4,356 per acre to 2,904.

GREEN MANURE SHRUB ESTABLISHMENT ON THE CONTOUR

This is another form of soil preservation but, if adopted, it is essential that a second sowing of seed should take place just above the first a few months before the original plants are eradicated or the last stages of the land in question will be worse than the first.

GRASS TERRACES AS OPPOSED TO THOSE CONSTRUCTED OF STONE

Paspalum dilatatum terraces can be effectively established throughout a property in a far shorter period than those of stone and have the further advantage of costing a great deal less. They are actually more effective in that the soil further collects as the grass

takes root therein and the height is continually increasing which is not the case with stone terracing. One often notes these Paspalum terraces established above roads only and not above the field drains; this to my mind is not logical in that exactly the same conditions of breakdown can be noted above drains as above roads and the incidence above drains is far more.

Control of these Paspalum terraces is certainly an expensive matter but it is amply offset on an estate where a ground cover is in existence by the great saving in drain cleaning. My experience is that these terraces require to be trimmed back effectively at least once in two years.

TEA HEDGES ABOVE ROADS AND DRAINS

A better way still of establishing permanent terraces above roads and drains is by means of tea hedges, initiated by the use of:—

(a) Backward and root-twisted plants discarded from nurseries.

(b) Self-sown tea plants which can be found in the fields nearing the pruning period, especially from fields of a low jât variety.

The effect of soil collection from tea hedges can best be seen after pruning in instances where these have been established on many estates in the Lindula section of the District of Dimbula.

CONTOUR PLANTING OF SHADE TREES

I do not note any great benefit from the point of view of soil erosion prevention in planting shade trees on the contour. I do however prefer planting these on the contour below drains because, planted thus, the mortality of young plants can be more effectively noted as one has only to walk along definite drains to find them.

DRAIN CONTROL

The Open Drain and Its Action.—It is now universally agreed that free run-off of water by means of open drains in districts of moderate rainfall such as Dimbula and Upper Dickoya is wrong in principle. Existing drains of this nature can at no very great cost be converted to hold up water. The more common methods are:—

(1) By establishing bunds in existing drains.

(2) By cutting out pits on the reverse slope principle.

To my mind the cheaper and more effective method is that of levelling the bottom of the drain in sections of six to the chain on slopes of 1 in 15 to 1 in 20 and using the resulting earth to form bunds on

which Paspalum grass can be established to prevent the bunds washing away. These insure a very even distribution of water for eventual seapage to the tea roots below. The late Mr. C. E. A. Dias was the originator of this system.

The reverse slope principle when first cut is certainly the neater to view, but on clean-weeded estates it will be found the silt gathers in the pockets and, unless this receives immediate attention, the system reverts to that of the bunded drain. My experience has been that a man will for a day's name cover about double the length of drain under the former system as under the latter.

Main Drains or Nettikhans.—I do not think it is fully realised what the evils of ravining are where drains which run directly down hill are kept clean. The best method to prevent this evil is, to my mind, first to encourage these drains to fill up by bunding them at intervals, and then to establish a carpet of *Paspalum dilatatum* which acts as a "sponge hold-up," gradually dispersing the water later. This method of control, particularly in areas where there is a ground cover in the tea, results in the necessity for putting in far fewer culverts in any cart road below.

Where the land is very steep, further measures will be found necessary such as cutting reverse slope pits at intervals in the course of the drain or even adopting the water cushion system described in the Soil Erosion Report and illustrated therein. This was initiated by Mr. John Horsfall, and the principle is that a stone step sloping backwards is established with a projecting lip so that the rate of flow of water is reduced to a minimum and the water drops vertically from one step to the next.

PROTECTION OF RAVINES

Ravines, too, especially if they run down steep land, should carry a carpet of grass of some sort to help to hold up water; this with the object of prevention of flooding during the heavy spates of rain. *Paspalum dilatatum* grass is useful for this purpose up-country and has the additional advantage of providing good fodder for the cattle of the labour force in addition to that provided by the Paspalum soil barriers above roads and drains. Spaces can be kept clean round gum plants and should sunflower be required for provision of compost from areas other than where the tea is growing, this can be established by planting the cuttings in the grass.

WEED COVERS

We now come to the main provisions for prevention of soil erosion, those mentioned previously being in the nature of a second line of defence.

The only way to prevent erosion at its source is by means of establishing ground covers *in situ*, unless the estate has a good stand of *Grevillea robusta*; the latter is generally the case in a district like Uva, where ground covers are not so easy to establish owing to long periods of drought. Grevillea has the double advantage of providing a means of breaking the intensity of rainfall before it reaches the ground and, being very deciduous, the continual leaf-fall provides a wonderful carpet to the ground. If, however, Grevillea be established sufficiently close to be efficient in the above respects, it will be argued that the shade caused will be a factor against good quality teas being produced for reasons which need not be gone into in this article.

METHOD OF ESTABLISHMENT OF GROUND COVERS

The method I have adopted is first to allow every species which *wants* to grow to establish itself except the varieties which are suspect for particular reasons. The latter are at the moment the following:—

(a) *All kinds of grasses*—including of course Cootch and Illuk. The reasons for keeping out the two latter are obvious.

(b) *All soft weeds* which grow up through the ground cover. Though I do not argue that they compete to any extent with the major crop, I eliminate them as not being to my mind a type of true ground cover and, besides, the general distribution of flowering weeds throughout the tea areas has a psychological effect and gives an appearance of abandonment.

(c) *Desmodium triflorum*.—This is apt to form too close a carpet and, unless heavily forked at least once in 12 months, certainly has a deleterious effect on the tea.

(d) *Artemesia vulgaris*.—This is what is commonly known as the Chrysanthemum weed and is considered too deep rooted. I do not however consider that it has been established that it has harmful effects for this reason. I would bring forward the argument that deep-seated roots of ground covers (and, for that matter, of shade trees and bush plants as well) are always gradually decaying and affording channels which are useful from an aeration point of view.

(e) *Centella asiatica.*—This is commonly known as the violet weed. The objections with regard to this are the same as those set forth under section (d) above.

(f) *Plantago asiatica.*—This is akin to the lawn plantain in Europe and has the same objections as those given under section (d).

Using the method adopted by me the following will eventually be found to predominate in most estates in Dimbula:—

(i) *Drymaria cordata.*—This is objected to by many Visiting Agents on the score that it is untidy and has a distinct tendency to creep up through the bushes and establish itself on the plucking surface. My reply to this is that it can quite easily be prevented from doing this by insisting that the weeders each month scrape it away from the bowls of the bushes. A karandy can be used for this purpose where the cover is thick because the soil thus shifted cannot go very far. Complete elimination of *Drymaria cordata* is a very expensive and very often impossible undertaking.

(ii) *Justicia procumbens.*—This forms a very efficient ground cover if only the weeders are taught to let it establish itself. It has a very high returned-nitrogen content — equal to that of the sun flower. It also, like *Drymaria cordata*, has a fine root system but, unlike Drymaria, can be quite easily eliminated if that were at any time required. It also has a tendency to climb up through the tea bushes if not controlled in the way mentioned above. The low cost of control of ground covers with this tendency is set forth further on in this article.

(iii) *Biophytum proliferum.*—This is indigenous on many estates, at any rate towards the upper end of Dimbula, as can be seen by careful examination in ravines where the weeding scraper is not brought into play. It establishes itself fairly quickly, though not so quickly as the two varieties mentioned before.

The above three are the most likely to establish themselves at the expense of other varieties which have been left alone.

We now come to the more easily introduced varieties which become predominant among other ground covers:—

(iv) *Oxalis corymbosa.*—A description of this and the two following varieties will be found towards the end of

this article. If this has not already become established it is fairly easy to achieve this object by continually strewing its bulbs behind the forkers.

(v) *Oxalis latifolia.*—The same remarks apply with regard to this as to *Oxalis corymbosa.*

(vi) *Fragaria indica.*—This is a wild strawberry, the fruit of which is tasteless. This is an advantage in that the labour force does not pick the fruit and this, having a multitude of seed on its outer surface, has a tendency, when leaving the plant in a ripe state, to roll down hill, sowing itself and establishing very quickly. This forms an excellent ground cover and ultimately appears to stand alone.

I admit that none of the six above varieties are legumes and can only say again that I have not been able during a period of years to establish a really successful cover of a leguminous variety.

There is a school of thought which prefers to endeavour to establish only two, or at the most three, varieties of leguminous varieties as ground cover. All I can say is that I hope they will be successful in their efforts.

METHODS OF CONTROL

In order to prevent matting it is very necessary that the land should be forked well at least once in twelve months. That means that a normal regime of forking alternate lines every six months would suffice. The artificial manures more commonly used in these days, if spread first over the ground cover, have a distinct tendency to make the latter wilt; this has the great advantage of affording an easy means of checking whether it has been evenly spread. The forking then takes place and as much of the ground cover and manure is buried beneath the fork as possible with other green stuff. Ground covers which have a tendency to climb up through the bushes must be scraped away *monthly* as explained before. Soft weeds, as they show up through the ground cover, are hand gathered and taken to the nearest road *monthly*. Grasses and any other ground covers which it is considered desirable to eliminate are attended to *once a year*, in the dry weather for preference, by a special gang under strict supervision.

Paspalum dilatatum soil barriers and edges of grass ravines are cut back carefully at intervals of 24 months.

COSTINGS

It is often stated that the cost of weeding in tea where ground covers are the order of the day, will be very high. This has not been my experience. Latterly I have paid the weeding contractors Rs. 1.25 per acre per month during the four wettest months and Re. 1.00 per acre during the remaining eight months. This work includes careful hand weeding of all soft weeds appearing and the scraping away of ground covers which have a tendency to climb round the bowls of the bushes. The cost of the control gang which goes round the whole area during January, February and March works out as a rule at about Rs. 3.60 per acre, or an average over 12 months of 0.30 cts. Add to this the monthly cost of the monthly control, 1.08 cts., and the resulting total cost comes to 1.38 cts. Rs. 1.60 per acre per month is the inclusive estimate and the balance, .22 cent per month, is taken up in the wages of the supervising K.P. and in such odd jobs as the collection of weed material into heaps for compost purposes, etc. The actual cost per acre works out in practice at between Rs. 1.50 and Rs. 1.60, and I am inclined to think that this is cheaper than the average weeding bill on clean weeded estates in the neighbourhood.

The cost of Paspalum control is not included under this head and it would vary between Rs. 1.50 and Rs. 2.00 per acre on the average over the whole area, between Rs. 3 and Rs. 4 per acre being spent on half the area in alternate years. This, as I have mentioned, is offset by a very considerable saving on upkeep of roads and drains.

DEMONSTRATION GROUND COVER PLOTS

I by no means claim that after nine years I have discovered the varieties of ground cover which will eventually prove to be the best. I have been responsible now for the establishment of about fifty different kinds of possible ground covers in plots for investigation purposes, some of which have been also established actually under tea. I would therefore urge that similar plots be laid down on estates for further investigation of their habits.

SPECIES ACTUALLY FOUND TO GROW

Below will be found a list of species actually found to grow in the district of Dimbula at an elevation of about 4,400 feet. Against each variety I have put down further information I have collected in the way of vernacular names, habits noted, and medicinal properties.

I might add that a good number of the plants mentioned below will be found illustrated, but not in colours, in a recent excellent publication of the Department of Agriculture called "The Kandy Flora."

Achynanthes sp.—Identification requires confirmation; a promising ground cover having roots on the nodes; probably indigenous.

Aeschynominae americana.—Probably indigenous.

Alternanthera sessilis.—Tamil, Poonankani, Sinhalese, Mukunu-henna; Amarantaceae (Pigweed family); shallow rooted; used as a poultice for wounds and aches; boiled with onions used as a fermentation in Beriberi; also used with cummin for intestinal inflamation.

Artemisia vulgaris.—Tamil, Maru-kolunthu; Compositae; probably indigenous; deep rooted; this has been confused at Kew with the tall-growing Artemisia with the same leaf shape which is found growing round line vegetable gardens, but Macmillan in his book on gardening differentiates between them. The leaves of vulgaris, if bruised, have a very pungent scent.

Atylosia rugosa.—Leguminous, Papilionaceae; grows freely on the Bo-Pats but does not appear to thrive under tea.

Cardamine hirsuta.—Tamil, Kadukup-pillu; Cruciferae; probably indigenous; apt to die off under drought conditions.

Cassia mimosoides.—Sinhalese, Bin siyambala; probably indigenous; promises well as good leguminous cover on certain estates.

Cassia kleinii.—Introduced; apt to form too much of a carpet at times; also apt to die out.

Cassia leschenaultiana.—Leguminous, Caesalpiniaceae; has too extensive a root system and grows too high and rank; also subject to sooty mould.

Centella asiatica.—Sinhalese, Gotukola, Heen gotukola, Makulu-venna; Tamil, Vullarai-pillu, Elekalu-pillu; probably indigenous; apt to form too thick a carpet. Bundles of the leaves can be bought in the caddies at 1 cent per bundle for medicinal purposes — for worms and as a tonic.

Centrosema pubescens.—Leguminous, Papilionaceae; introduced; apt to climb.

Desmodium heterocarpum.—Sinhalese, Et-undu-piyali, Leguminous, Papilionaceae; a preparation of this is used as a restorative after fainting and convulsions; also used for poulticing sore breasts; a decoction is used as a cough cure and as a tonic.

Desmodium microphyllum (*D. parvifolium*).—A rather promising ground cover; small-leaved and shallow-rooted; probably indigenous.

Desmodium triflorum.—Tamil, Narunkody, Soory pillu; Sinhalese, Hin-undu-piyali; probably indigenous; apt to form too tight a carpet.

Euphorbia hirta.

Fragaria indica (wild strawberry) Rosaceae; probably introduced; a splendid ground cover and easy to establish.

Hedyotis corymbosa.—Tamil, Imbura siyavaputhai; is used as a cough cure.

Hedyotis monosperma.—Tamil, Peenara kody; Rubiaceae or Madder family; probably indigenous; forms a good ground cover; the crushed leaves have a very offensive smell.

Hedyotis nitida.—Sinhalese, Pita-sudu-pala; probably indigenous; the leaves are chopped up, boiled and eaten with rice.

Hydrocotyle javanica.—Tamil, Meen vullarai; Sinhalese, Val gotukola, Wahakola; Umbelliferae; large leaves; does not spread easily and does not climb.

Hydrocotyle manii.—Tamil, Sinna vullarai; probably indigenous; leaf intermediate between *H. javanica* and *H. sibthorpioides* but varies in size; establishes fairly easily as a good ground cover.

Hydrocotyle sibthorpioides.—Tamil, Kussup-vullarai, Kullai vullarai; has a very small leaf; prefers damp situations.

Indigofera endecaphylla.—Leguminous; introduced; apt to die away after a period of years; climbs.

Justicia procumbens.—Tamil, Ottu-pillu, Poom-pillu; Sinhalese, Mayani; Acanthaceae; probably indigenous; has a tendency to climb but is a splendid ground cover; root system fine and feathery; high nitrogen content, 5 tons of green matter returning about 78 pounds of nitrogen; has been seen thriving under drought conditions in the Jaffna Peninsula.

Laurembergia wangerinii.—Tamil, Tunnai parsun, Podithallai; Haloragadaceae; apt to die out if exposed to too much sunshine.

Osbeckia sp.—Probably indigenous; rather similar to *Richardia scabra.*

Oxalis bowii.—Introduced; long, thin bulbs and a large red flower.

Oxalis corniculata.—Tamil, Sinna puliyari; Sinhalese, Ein-embul-embiliya; leaf is bronze or green; does not form as thick a cover as other Oxalis varieties; no bulbs.

Oxalis corymbosa.—Tamil, Periya puliyari; Sinhalese, Loku-embala; Oxalidaceae; introduced and cannot now be eliminated where established; heart-shaped leaflets with rounded corners; root system bulbous; used as a salad by labourers.

Oxalis latifolia.—Tamil, Puliyari; introduced and cannot be eliminated; triangular acute-angled leaflets; root system bulbous; also used as salad.

Parochetus communis.—Tamil, Arlankoddai; leguminous; probably indigenous; difficult to establish in Dimbula; is apt to die out when tea is pruned; has a tiny blue pea flower and a leaf similar to Oxalis but with a dark midrib.

Phyllanthus urinaria.—Tamil, Chivappuk-killay-nelli, Keelkunellai; Sinhalese, Rat-pilavakka; Euphorbiaceae (Spurge family); probably indigenous; resembles the sensitive plant in appearance but the leaves are not sensitive.

Plantago asiatica.—Tamil, Punnai pillu; Plantagineae or Ribwort family; probably indigenous; deep-rooted; is of the same family as the lawn plantain in Europe.

Polygonum nepalensis.—Tamil, Kangany-machan-pillu; Polygonaceae; indigenous; is not perennial; forms a splendid cover at times and rapidly re-establishes itself from seed; dies back under heavy shade or in drought.

Pouzolzia triandra.—Urticaceae; probably indigenous.

Pouzolzia zeylanica.—Urticaceae; probably indigenous; quite promising as a ground cover; has small leaves and is shallow-rooted; the leaves are eaten as a vegetable and as a cure for worms; also used as a poultice for sores; the juice is used to encourage arrested flow of milk.

Pueraria javanica.—Leguminous; introduced; apt to climb.

Pycnospora lutescens.—Leguminous; rather like *Desmodium triflorum* but not so close-matted.

Ranunculus wallachianus.—Ranunculaceae or Buttercup family; prefers damp situations and is therefore likely to die out in the open when a field is pruned.

Richardia scabra.—Rubraceae; probably indigenous; is very firmly rooted and is establishing itself considerably in parts of Uva; might prove an excellent ground cover for the dry zone; also known as Mexican clover and considered by some to be a good cattle fodder.

Sedum sp.—Crassulaceae; dies off under dry conditions.

Sida rhombifolia.—Tamil, Atipala-cheddu, Peria pullam parsai; Sinhalese, Kotikan-bevila; Malvaceae or Mallow-family; probably indigenous; grows too high to be a good ground cover; heavy root system; used by the Tamils as a headache cure and considered by the Malays to have magic properties; formerly believed in Europe to be of value in pulmonary tuberculosis and rheumatism but this is now said to be unjustified; root decoctions also used for fever, stomach complaints and irregular menses.

Sindernia rotundifolia.—An extremely small variety of ground cover but not likely to withstand drought.

Spilanthes acmella.—Compositae; probably indigenous. rather too woody to be a good ground cover.

Synedrella nodiflora.—Tubiflorae; fine rooted and promising as a ground cover; used for poulticing and as an embrocation; the juice is used for earache; probably indigenous.

Torenia cyanea.—Scroppulariacea (Figwort family); probably indigenous.

Vigna oligosperma (*Dolichos hosei*).—Leguminous, Papilionaceae; apt to climb.

FURTHER GENERAL OBSERVATIONS

A table of approximate percentages of returned nitrogen, kindly supplied by Dr. Joachim of the Department of Agriculture, is not repeated here but may be found by those interested on page 208 of Vol. X, Pt. 4 of *The Tea Quarterly*. I am not in a position to make any authoritative statement as to whether it is better from the point of view of moisture competition in dry weather for the major crop

to have a ground cover which defoliates or does not do so. From the point of view of effective elimination of grasses and other undesirable growths, however, the variety which defoliates in dry weather is the better. I might add here that *Drymaria cordata* has this advantage of defoliation and a further advantage with regard to its root system. This is that, though light in texture, the roots are very numerous and tenacious of the top soil surface, thus preventing dry erosion during drought and wet erosion when the first rains descend, the plant bursting into full foliage almost immediately after.

There is one disadvantage with regard to ground covers and that is in relation to the supplying of old tea. Unless extremely careful attention is continually paid to cleaning away the cover round the holes, planting by seed-at-stake or by basket plants is not advisable. On the other hand, lengthy two-year-old stumps come to no harm in a ground cover.

Efficient stopping of soil erosion can only be effected *at the source* and the most logical way in which to achieve this object is by means of ground cover. Other control measures should be considered more in the light of a second line of defence.

The ideal non-climbing legume has apparently not yet been found. Are we to continue to wait until this is found or would it not be better to utilise non-leguminous ground covers and, if of a climbing variety, to control them ?

Note.—When sending specimens to the Economic Botanist for identification, the following instructions should be observed:—

1. *What to send.*—The following should be included if possible: Specimens of bud and flower attached to stem; also mature fruit and leaf-bearing twigs, including matured as well as tender leaves. Also roots.
2. *Information required.*—The name and nature of the locality where the plant occurs should be given; also the local names of the plant and its nature (whether herb, shrub, tree, etc.) Whether it grows wild or is cultivated (if cultivated, its origin should be stated if possible). The colour of the flower, the uses of the plant and any other points of interest should also be included.
3. *How to send.*—Large specimens should be wrapped in plantain leaves to keep them in fresh condition or they can be pressed in folded sheets of blotting paper.

   Small hardy specimens may be sent in ordinary envelopes but small delicate specimens should be pressed in folded sheets of blotting paper.

A NEW TYPE OF DIRECT-FIRED AIR HEATER FOR DRYING TEA*

CONTRIBUTED BY THE SHELL CO. OF CEYLON, LTD.

WITH A FOREWORD BY R. C. SCOTT

I have been asked by Messrs. the Shell Co. of Ceylon, Ltd., Colombo, to write a short introduction to an article on the direct-fired heater for drying tea that is installed in Ottery Factory, Dickoya, Ceylon; it is with great pleasure and satisfaction that I do so.

The construction and working of the furnace are explained in the following memorandum by Messrs. the Shell Co. of Ceylon, Ltd. I have little to add to the comments made except to say that I fully endorse them.

At the end of the memorandum are listed the advantages of the direct-fired heater; the only disadvantage I can name is the fact that, since the heat is applied to the tea in the drier direct, it is not possible to use a fuel other than oil for heating. With always the possibility that one may not be able to obtain a supply of liquid fuel, it is necessary to have a drier with the ordinary tubular form of heater available in which one can use either firewood or coal.

As stated, the drier with the direct-fired heater has been in regular use since June, 1938. Certain interesting figures are given; these I supplement with others showing the cost of firing made tea (fuel only), viz:—

June-Dec.	(incl.) 1938.	0.69	cent per lb.	
Jan.-Oct.	,, 1939.	0.67	do.	
Jan.-Dec.	,, 1939.	0.71	do.	(a)
Jan.-Mar.	,, 1940.	0.85	do.	(b)

(a) price of liquid fuel increased by 7 cents per gallon since November, 1939 (inclusive).

(b) in addition to (a), crop was very short owing to drought prevailing.

* The Institute does not necessarily endorse the views expressed by contributors other than members of the staff.

As regards the prices obtained for the teas directly fired, such have been regularly satisfactory and compare most favourably with the highest being obtained by surrounding estates.

The economy obtainable by this method of firing is obvious; the maintenance charges are quite negligible, and so is the danger of fire since one has no tubes to cause one apprehension; neither is there danger of sparks being emitted from the chimney which is always cool, since the chimney damper is fully closed except for 5-10 minutes when the burner is lighted and this very readily.

I can confidently recommend the installation of a direct-fired heater, and shall be pleased to demonstrate that in my factory to anyone interested.

Requests for such demonstrations should be made through Messrs. the Shell Co. of Ceylon, Ltd.

ROBERT C. SCOTT.

A NEW TYPE OF DIRECT-FIRED AIR HEATER FOR TEA DRIERS

The orthodox air heater for supplying hot air to tea driers consists of nests of cast iron or steel tubes built on both sides of a fire box. The products of combustion are passed through or over the tubes while the air for drying the tea is drawn over or through these heated tubes. During the life of the stove considerable sums of money are spent on repairs to and renewals of these air tubes.

This type of heater has been in use for a great many years and while it has been satisfactory it cannot be considered as the most efficient machine for the purpose. The steelwork requires a fair amount of fuel to raise it to firing temperature and a lesser quantity to maintain it at that temperature. Usually the time taken to raise the temperature of the machine to that required for firing is one hour. During the process of raising and maintaining the temperature of the machine a certain amount of heat is lost by radiation.

If it is possible to reduce the time required to raise the temperature of the machine to firing temperature and to reduce the loss of heat due to radiation, there will be a saving in fuel consumption. Also if the air tubes can be dispensed with the maintenance costs will be reduced considerably.

Some years ago a new type of air heater was developed in Java in which there were no metal air tubes but the products of combustion were passed direct from the combustion chamber (fire box) into the tea drier. The fuel used was oil. A number of these machines have been in constant use in Java for several years with great success. It was found that due to perfect combustion obtained with oil the leaf was untainted even though the products of combustion were passed through the tea. At times there is an abundance of cheap firewood available in Java and on these occasions the direct-fired heater is not used because it is obviously unsatisfactory to use firewood in a direct-fired heater, because of the ash and possibility of fire due to hot embers being drawn through the machine.

The risk of setting fire to the factory when using an oil-fired direct-fired heater is negligible, in fact there is probably less risk than when a tubular stove which is fired with solid fuel is used. When firewood is used in an indirect heater it is possible for red hot embers to be carried up the chimney where they might be drawn up to the withering lofts. In the direct-fired heater all the fuel is burnt in the combustion chamber in front of the baffle wall and there are no hot embers to be drawn from the liquid fuel.

The brickwork of a direct-fired heater is always cool, which is an advantage in the drying room.

In 1936 the first direct-fired heater in Ceylon was installed at Ottery Estate, Dickoya, by Mr. R. C. Scott, with the approval of the Factory Fire Insurance Company and without any increase in the premium. This heater was designed by the Shell Company's Technical Department and differs from the Java heater in one or two respects. The Java heater broadly speaking consists of a wide metal tube bent at right angles, the metal tube being brick lined with four oil burners tangentially placed at the base. The heater installed at Ottery Estate is built entirely of firebrick and is fitted with only one low-air-pressure burner. Figure 1 shows a section and front view of this heater. Broadly speaking the Otttery direct-fired heater consists of an inner and outer firebrick chamber, the inner chamber which forms the combustion chamber extends about half the length of the outer chamber, the oil burner being fitted to the front of this combustion chamber. Perfect combustion of the oil takes place in the combustion chamber and air in sufficient quantities to dry the leaf is drawn through the ducts or passages formed between the walls of the inner and outer chambers. A thorough inter-mixing of the cold air and hot gases from the combustion chamber takes place at the back end of the outer brick chamber, the inter-mixing being assisted by a baffle wall of firebrick. The mixture of air and products of combustion at this point is now

at a temperature of about 200°F. and is passed directly from here through the machine in which the leaf is dried.

The direct-fired heater on Ottery Estate was built in May, 1936 to supply hot air to an old medium sized drier which had not been in use for some considerable time and was erected by the estate mason under the direction and supervision of a member of the Shell Company's Technical Staff. An ordinary brick bulking chamber was erected between the stove and the drier which acted as an additional mixing or bulking chamber for the air and at the same time formed a convenient support for the chimney. A damper was fitted in the base of the chimney and another damper in the air duct leading to the drier, the two dampers being inter-connected so that when the chimney damper was open the drier damper would be shut. The object of this was to allow products of combustion to be passed up into the atmosphere when the burner was first lighted up. It was purely a precautionary measure to prevent the possibility of tea being contaminated by unburnt fuel. Ten minutes after lighting up the burner the stove was sufficiently hot to prevent any possibility of any fuel being imperfectly burnt and the machine was ready for firing the tea.

The accompanying illustrations show how simple is the construction of this type of air heater.

Figure 1 shows a section and front view of the direct-fired heater.

Figure 2 shows the estate mason laying the foundations and floor of the new stove.

Figure 3 shows the side and back walls nearly completed. The circular hole in the back wall is the duct through which the hot air passes into the drier.

Figures 4 and 5 show the finished stove. The cylinder on top is the burner atomising-air receiver and is so placed for lack of convenient space elsewhere. The low-air-pressure burner with automatic cut-off is clearly shown here. On the right of the burner a U-gauge can be seen which registers the pressure of the atomising air at the burner in inches water gauge. The chimney can be seen in the background.

Figure 6 shows the ordinary brick bulking chamber erected between the stove and the drier, and the hot air duct between the bulking chamber and the drier.

Figure 7 is a view taken from the front of the drier and clearly shows the drier, brick bulking chamber and chimney.

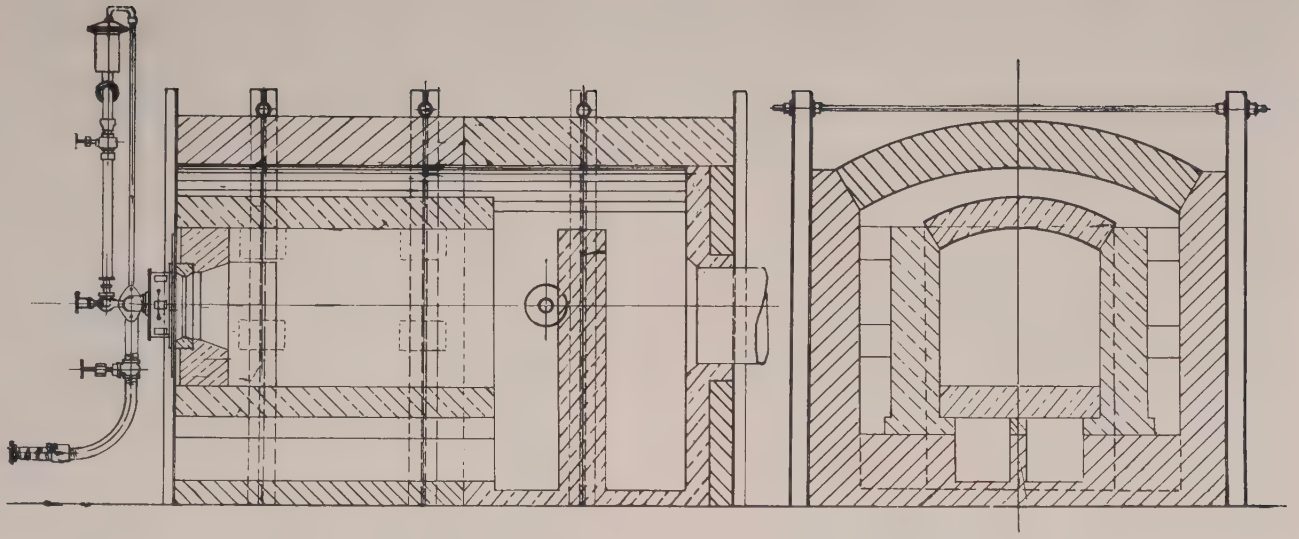

Fig. 1

Fig. 2

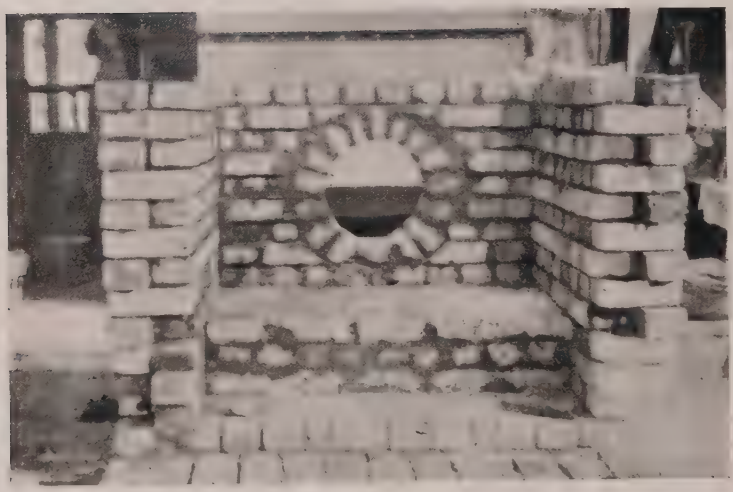

Fig. 3

Fig. 4

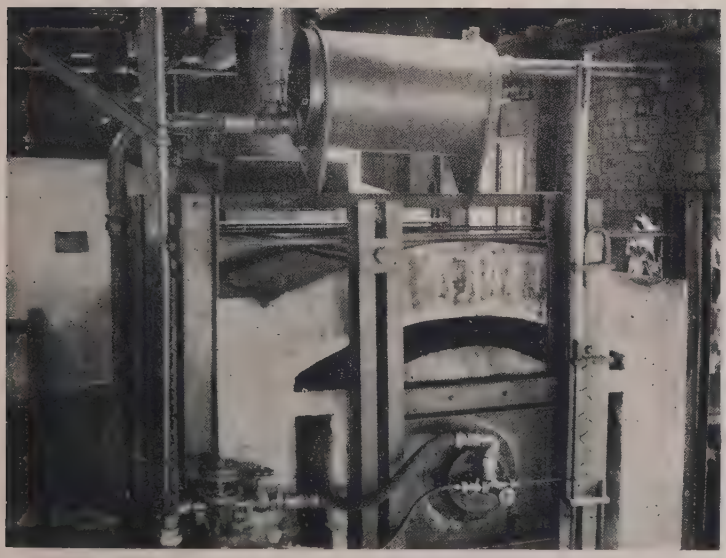

Fig. 5

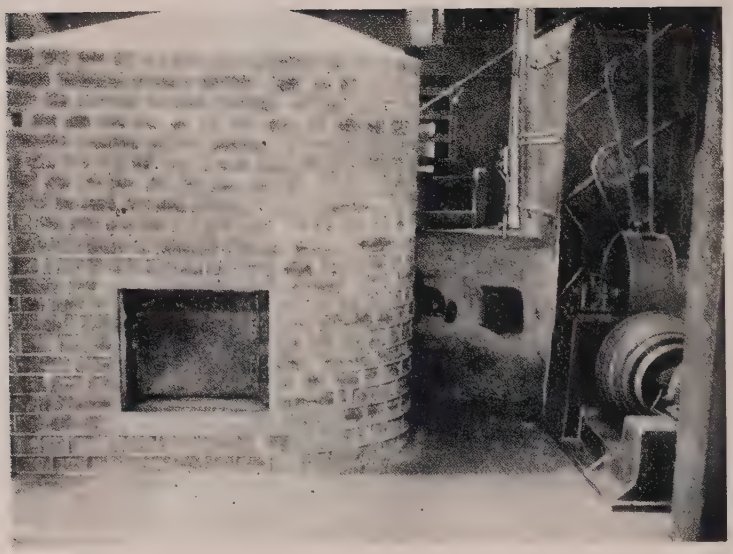

Fig. 6

Fig. 7

A number of experiments were carried out with the heater and drier and later in the year the drier was put into commercial production with most satisfactory results as far as the heater was concerned. The drier was an old one and its performance was unsatisfactory, partly due to an abnormal amount of leaf "fall through" which necessitated leaf being withdrawn from the bottom and passed through the drier two or three times. This, of course, reduced the out-turn of the made tea per gallon of oil. The average out-turn of the drier under these conditions was 39.8 lbs. of made tea per gallon of fuel used and 39 lbs. of moisture evaporated per gallon.

The machine continued in full commercial production until early 1938 when Mr. Scott, the proprietor of the estate, decided to install a modern 4 feet drier with the area of the trays reduced to 3 feet in place of the medium sized drier.

The only alteration necessary to the direct-fired heater was to increase the area of the outlet for the gases.

In April, 1938 the machine was again placed in commercial production, and has been continuously in use since that date.

Between June, 1938 and April, 1940 the direct-fired heater has produced 536,737 lbs. of made tea with an average of 42.87 lbs. per gallon of oil used, the average quantity of moisture evaporated being estimated at 42 lbs. per gallon.

In analysing the figures it was interesting to note that, provided the drier is run at something approaching full capacity, the lbs. of tea obtained per gallon of oil is almost independent of the number of firing hours. With indirect types of air heater, which are fitted with metal air heating pipes, the amount of heat, and therefore fuel required to raise the stove, etc. to firing temperature, is such that, unless the drier is operated for several hours, the lbs. of made tea produced per lb. or gallon of fuel is very adversely affected.

During the twenty-three months during which records have been kept the first two months' out-turn of made tea per hour was 105 lbs. and 109 lbs. respectively and the lbs. of made tea per gallon was 30.4 lbs. and 35.37 lbs.

When the out-turn per hour was raised to 126 and 144 lbs., the lbs. of made tea per gallon rose to 44.8 and 51.26 respectively.

To sum up, the advantages of the direct-fired heater are :—

(1). It is less costly to build than a tubular stove.

(2). There are practically no maintenance charges — even for an iron chimney since mild heat passes up it for only 5-10 minutes after the burner is lighted.

(3). It can be built for any size or type of drying chamber.

(4). It is very economical in fuel consumption.

(5). There is a great saving in time and fuel in raising the tea drier to firing temperature.

(6). The out-turn of made tea per gallon of oil used is almost independent of the number of hours the drier is in use.

(7). There are fewer radiation losses from this type of stove, thus making for a cooler firing room.

(8). Steady firing temperature can be maintained due to the quicker temperature response of the direct-fired heater to burner control.

A NOTE ON THE LIFE OF DRIER TUBES*

D. W. FINLEY, B.A., B.Sc.(Oxon.) A.M. Inst., B.E.

In the air heater attached to the most usual type of tea drier the hot products of combustion pass through a series of tubes and up the chimney. The air to be heated is sucked over these tubes. Heat passes from the hot furnace gases through the tubes to the cold air. During normal firing a fairly steady heat transference will occur, resulting in the inside of the drier tubes being hot simultaneously with the outside being cold.** This difference in temperature of the two sides of the tubes results in a 'temperature gradient.' Those tubes nearest the furnace will be much hotter inside than those nearest the chimney. In the latter tubes wear is caused by scaling, a form of corrosion due to condensation, whereas in the former tubes the inside is too hot to permit condensation and wear is caused by burning.

In a drier too ambitiously designed, heat can be so effectively removed from the chimney gases that condensation occurs. Analysis of a sample of the liquid that drips out of the stove has shown that

* The Institute does not necessarily endorse the views expressed by contributors other than members of the Staff.

** In those stoves in which the cold air passes through the tubes instead of outside them, the same principle applies, although the direction of the flow of heat will be reversed, condensation occurring on the outer surface of the tubes.

this may be a 4.2 per cent solution of iron acetate.[1] Rapid disintegration of drier components is bound to follow. This can be prevented by slightly increasing the chimney draught. Combustion will be accelerated and, since the heat demand of the drier does not change, the surplus heat will go up the chimney, keeping the inside of the tubes warm enough to avoid condensation.

It is not generally recognised that the products of combustion from liquid fuel, coal and firewood all contain water vapour. The fuels all contain hydrogen, which burns to water, and carbon, which burns under good conditions to form carbon dioxide.[1] The proportions formed by dry fuels are given below.

TABLE I

PRODUCTS OF COMBUSTION OF DIFFERENT FUELS

Fuel	% Combustible Hydrogen	Lbs. water formed per 100 lbs. dry fuel
Coal (Ceylon quality)[2]	5·5 %	49·5 lbs.
Liquid Fuel [3] ...	12·8 %	115·2 lbs.
Wood [4] ...	6·0 %	54·0 lbs.

In order to correlate the values given in Table I, the following assumptions have been made in Table II. A drier such as a 4-foot E.C.P., turning out 185 lbs. of made tea per hour, would consume fuel at the rates given in the table. These are based on figures actually obtained during tests, being the average of one day's firing (excluding lighting up) namely:—

(a) 2.35 lbs. of made tea per 1 lb. of coal.

(b) 40 lbs. of made tea per gallon of liquid fuel.

(c) 1.55 lbs. of made tea per 1 lb. of firewood.

TABLE II

WATER PRODUCTION PER HOUR

Fuel	Fuel used	Lbs. of water formed even if fuel is completely dry
Coal ...	78·7 lbs. per hour	39·0 lbs. water per hour
Liquid fuel ...	4·6 gallons per hour (app. 41·4 lbs.)	47·7 lbs. water per hour
Wood ...	119·4 lbs. per hour	64·5 lbs. water per hour

From these figures it is quite obvious that a good deal of condensation can occur with any fuel if conditions favour it. In a normally designed furnace, condensation should not occur under working conditions. But there is one factor, not generally recognised, that frequently leads to condensation with any fuel. It is the intention of this note, having shown that water may be condensed from the products of combustion of any fuel, to call attention to this little recognised cause of stove wear.

When a drier is being started the tubes nearest the smoke-box are naturally the last to warm up. If the air fan is started too soon these tubes may be cooled off so rapidly that condensation occurs. This particularly applies to cases where the drier damper is opened suddenly to its fullest capacity. While coolies have in most factories been trained to open up this damper slowly when firing is about to begin, withering is not always commenced with the same care.

Condensation can be caused also if there is a gap between withering and firing. Possibly very little leaf still requires the assistance of hot air for withering, and the cooly may allow the fire to die back without altering the fan damper position.

Secondly, even with fuel that is quite dry, condensation may occur if air is heated for withering, using the drier with the damper full open, but with the air below a temperature which in some cases is 150°F. This indicates that so much air is coming into the drier that the tubes are cooled enough to cause condensation. Condensation would not occur during final firing, since a very much smaller quantity of air is being drawn over the tubes, the heat of which is therefore maintained.

In many cases only very little water actually appears outside the drier, but the first few drops indicate that so much water has been condensed that the ash on the tubes and in the flues can no longer soak it up. The damp ash has a corrosive effect on iron, and the condensed water will dissolve out acids from the products of combustion, especially when firewood is being burned.

PREVENTION OF CONDENSATION

The above causes may be prevented by correlating the size of fire with the quantity of air drawn over the tubes.

(1). If it is necessary to use a big drier to produce a small quantity of heat, it is far better to use half the quantity of air at 165°F. than the full quantity of air at 120°F.

(2). When fires are being reduced, the fan damper should be progressively shut down, aiming at keeping the hot air at a minimum of 155°F. if the damper is at all fully open.

These remedies depend on the fact that the temperature of the air leaving the stove is raised, so that less load is placed on the bank of tubes nearest the furnace. Consequently more heat can be sent to the tubes nearest the smoke box, where the air to be heated is coldest and more likely to cause condensation. This restores the temperature gradient.

In both cases the regular removal of ash will minimise the deleterious effects of condensation, and drying of the fuel will reduce its likelihood.

SUMMARY

(1). Water may be condensed from the products of combustion of any fuel, even if the fuel is perfectly dry. Condensation takes place if the furnace gases come into contact with a sufficiently cold surface. It rapidly corrodes iron work.

(2). Corrosion may occur by overheating the stove.

(3). By reducing the quantity of air to be heated, the temperature gradient in the tubes can be restored, even if the same amount of heat is removed. Condensation can thus be prevented.

REFERENCES

(1). Lamb — *Tea Quarterly*, 1936, Vol. IX, p. 48.

(2). Brame — Fuels, Solid, Liquid, and Gaseous, p. 32.

(3). Figures supplied by Messrs. the Shell Co. of Ceylon, Ltd.

(4). Kempe's Engineering Year Book 1937, p. 1,418.

GRADING TEA WITH STAMPED ALUMINIUM SIEVES

III.—THE ARNOTT FILTRATE SIFTER

J. LAMB

In previous articles[1] the use of stamped aluminium sieves for grading tea has been described in some detail. There is not any doubt that stamped aluminium is superior to ordinary mesh under comparable conditions. The study of its use has therefore been extended to different types of grading machines, in order to cover possible differences due to the action of the machine in which the sieves are employed.

This article deals with the results of tests on an Arnott Filtrate Sifter fitted with stamped aluminium meshes. The Arnott Filtrate Sifter is essentially a series of four sieves one above the other with a fifth and smaller dust sieve at the bottom. The sieves are fixed in a common frame which is vibrated by a rod driven from a crank running in an oil bath. The amplitude of the vibration is small and the frequency high. When ordinary mesh was employed in the machine, comparison with our normal sifting process employing stamped aluminium sieves was unfavourable since both Colombo and London tasters preferred teas from the normal process. The reported differences were not as marked as might have been expected since teas sifted over stamped aluminium have consistently received markedly better reports than those sifted on wire weave, and on this account differences due to the sifting action were suspected. Stamped aluminium sieves were therefore fitted to the Arnott Sifter and careful comparison made with the normal grading process in these circumstances.

For some time past we have repeatedly reported the different requirements of the Colombo and London markets as shewn in our experimental results. The Colombo market is particularly concerned with the appearance of teas and anything approaching greyness prejudices its sale on that market to a greater extent than in London.

Standards of appearance accepted in Colombo are readily accepted in London and for the purpose of these grading experiments it has been considered sufficient to obtain Colombo tasters' opinion.

The sieves fitted to the Arnott Sifter were chosen so as to give the out-turn of various grades usual in St. Coombs factory and comparisons were made on this basis. Any other orthodox grading process can of course be copied by the choice of suitable sieves.

RESULTS

In the final tests the out-turn of grades was as follows:—

		Arnott %	Normal %
B.O.P.	...	58	57
F.P.	...	22	20
B.P.	...	3.5	2.5
P.	...	1.5	2.5
Fannings	...	10	12
Dust	...	2.5	3.5
Broken Mixed	...	2.5	2.5

The composition of grades determined by sifting on standard sieves was as follows:—

Particle size	B.O.P.		F.P.		Fannings	
	Arnott %	Normal %	Arnott %	Normal %	Arnott %	Normal %
Over 5			5	5		
Through 5 and over 8	8	14	73	60		
,, 8 ,, 10	39	30	11	17		
,, 10 ,, 12	26	27	11	18		
,, 12 ,, 16	20	22			16	17
,, 16 ,, 20	7	7			29	29
,, 20 ,, 30					45	44
,, 30					10	10

These mechanical analyses show that the Arnott Sifter is capable of producing the same percentage of grades and that the grades so produced have the same composition as grades normally sifted.

The tasters valued the teas graded as above at the following figures:—

	Arnott Cts.	Normal Cts.
B.O.P. ...	90	88
F.P. ...	96½	93
B.P. ...	78½	75½
P. ...	94	92½
Fannings ...	72½	72

London tasters would not make the same amount of difference, but the work of the sifter would meet with approval on that market.

Since grading is a multiple operation, involving not only machine sifting but also winnowing, picking and a certain amount of hand sifting, the actual rate of working of sifting machines cannot be compared directly. The work of the sifting machine may accelerate or retard the subsidiary processes if the grades are to be standardised, and on this account the output of the sifting room staff per day using either of two different sifting machines is the most accurate basis for comparison. Employment of the Arnott Sifter raised the output of the sifting room from 1,250 lbs. per day to 1,700 lbs. per day.

SUMMARY AND CONCLUSIONS

Teas sifted on an Arnott Filtrate Sifter, fitted with stamped aluminium sieves, have been carefully tested against a normal sifting process, normally employed for selling on the Colombo market where grading and appearance are of particular importance. The grades from the Arnott Sifter were practically identical in mechanical composition with the normal grades and the Arnott process was much quicker to work and simpler in operation.

The teas graded on the Arnott Sifter were approved by tasters and were valued higher on the Colombo market.

The Arnott Sifter was easily matched to an existing grading programme in the case described above by choice of suitable stamped aluminium sieves.

Any normal grading programme can be carried out on the Arnott Sifter fitted with stamped aluminium by reference to *The Tea Quarterly* (1939), Vol. XII, p. 179.

REFERENCES

(1). *Tea Quarterly* (1939), Vol. XII, 179.
(1937), Vol. X, 191.

SOIL CONSERVATION IN THE TROPICS

The following article, reprinted from the "Agricultural Periodical" (Monthly) of the Netherlands Society for Scientific Agriculture, 51st Vol. 1939, is a copy of a short paper read by Sir Frank Stockdale, K.C.M.G., C.B.E., Agricultural Adviser to the Secretary of State for the Colonies, at the request of the organizers of the Conference on Tropical Agriculture which was held at Wageningen, Holland.

As far as the British Colonial Empire is concerned, it is just sixty-five years ago since attention was directed to the question of soil erosion. It was in 1873 that Sir Joseph Hooker, then Director of the Royal Botanic Gardens, Kew, drew the attention of the Secretary of State for the Colonies to the serious losses of soil which were taking place in Ceylon as the result of the opening for cultivation of the forest-clad highlands of that colony. As the result of this action, legislation was some years later enacted prohibiting the alienation of Crown lands, except in small areas for very special circumstances, at all elevations in excess of 5,000 feet. Similar enactments were passed from the year 1912 onwards in the mountainous islands of the West Indies for heights varying from 1,000 to 1,500 feet according to the particular island concerned.

This system of protecting the forest cover at the higher altitudes of island colonies constituted the first steps which were taken in the British Colonial Empire to deal with erosion. It is satisfactory in the hilly wet tropics only if measures are also taken to prohibit the

opening of steep slopes and to protect the catchments and springs of the principal streams at lower altitudes. All lands opened for cultivation purposes must, however, be specially protected by anti-erosion measures if severe losses of top soil are to be prevented.

I personally began to take an active interest in soil conservation work in the tropics from 1920 when as Director of Agriculture in Ceylon it was apparent that much further protective work remained to be done on the tea and rubber estates in the hilly parts of that island if the enormous losses of soil from erosion were to be checked. The experiences of the Netherlands East Indies were freely drawn upon for control measures adopted and during my service in Ceylon I saw considerable advances made. Clean weeding practices were slowly, but gradually, abandoned, contour drains and silt-pitting increased, low contour stone walls established. the general growing of cover crops begun and the contour platform system in the opening of new lands started. Many were sceptical at first, but progress was made by degrees as the result of experiment, education and propaganda. The results achieved up to 1930 were reviewed by a special Government Committee constituted to examine the position. In the Report issued by this Committee in the following year there was expressed general commendation of the improvements which had been effected during the previous ten years but it was stressed that the position was still regarded as serious. Estate agriculture was considered to be mainly responsible for erosion in Ceylon and it was held that it was essential that the use of ground cover should be universally accepted, as it was only by the adoption of such a policy that erosion could satisfactorily be checked. In recent years, attention has been given also in the village lands and some useful demonstration areas started.

Since 1931 much attention has been focussed throughout the world on the problem of erosion and also on the measures which can be effectively employed to assist soil conservation. The position in the United States which was made clear to the world in the Report of the National Resources Board of 1934, and the action taken as the result of that report, have attracted universal attention. Those who were battling in the Colonies fifteen years ago to secure some recognition of the evils of, and losses occasioned by, erosion, have seen the Governments of colonial dependencies inundated with demands for something to be done and with complaints that anti-erosion work is not proceeding sufficiently rapidly. There is no British tropical possession in which a review of the position has not been made and, where necessary, some measures undertaken to improve matters. Public opinion has been aroused, but not infrequently the staffs available for the work are insufficient and finance inadequate. It

has been recognised, however, that considerable expenditure will have to be incurred and that the most satisfactory results will only be achieved when there is planned co-operation between administrative and technical staffs and the people themselves.

When questions of soil conservation are under consideration it is necessary to contemplate the issues involved in their broadest aspects. They must include not only the consideration of forest protection and anti-erosion measures but also those associated with the maintenance of soil structure and fertility. The reactions of vegetation on soil and possibly climate have their bearing on the general problem, as the whole concept of soil conservation covers the maintenance of its productivity. It is bound up with soil cover, the nature of the soil, the conservation of water supplies, the forestry position, the agricultural occupations of the people concerned and their social and tribal customs.

ACCELERATED EROSION

Accelerated erosion occurs in the form of sheet erosion, water erosion or wind erosion. It is brought about by an interference with the natural vegetal cover, by the omission of suitable anti-erosion measures and the lack of satisfactory methods of agricultural husbandry and of grassland and woodland management. The unthinking stripping of the soil's protective covering of vegetation is primarily responsible, but densities of population and developmental enterprises have required that large areas of hilly lands should be brought under agrarian production.

As far as the tropics are concerned, it is necessary to keep clearly in the forefront of any consideration of the subject the differences between the wet and dry tropics. It is necessary, however, to recognise that the distribution of the rainfall is of greater importance, as far as erosion is concerned, than the actual total falls. Downpours of high intensity over comparatively short periods of duration invariably cause the maximum of "run-off" and erosion is always more serious in areas where long periods of dry weather are experienced than in those where a more even rainfall distribution prevails. In some areas of the wet tropics erosion is not nearly so severe as might be expected because of its more regular spread throughout the whole year. Whereas in the dry tropics the soil during periods of drought is often reduced to dust which may be carried away by the wind or eroded by the heavy tempestuous storms which herald the break of the dry weather season, this dusty soil is but poorly absorbent and in consequence it takes little to remove it from its normal situation.

Again, the configuration of the country must be another factor to receive consideration. The steeper the slope, other things being equal, the less the time for water absorption and in consequence the greater the "run-off." The aspect of the slope is also important, for hilly slopes which face the direction from which prevailing rain storms come, suffer more than those which are favoured by a measure of protection. The size and shape of the watershed also must not be overlooked when the opening of lands from forest or grassland cover is under consideration and a decision being made of the anti-erosion measures to be adopted.

Consideration must also be given to the kinds of vegetation and the extent of the land cover. Forest cover is recognised as affording an ideal protection against erosion. Tree roots bind and hold the soil, leaves and branches break the velocity of the rains which would otherwise compact and erode the soil and the ground cover of forest litter provides that the water is rapidly absorbed, the velocity of surface water from hilly slopes reduced and "run-off" prevented It is the organic litter in the forest which encourages the absorption of water and checks "run-off," but at the same time the more satisfactory soil structure under the forest litter must not be overlooked. Soil under forest cover invariably has a better structure than is the case when a similar soil is subject to cultivation for a number of years.

It should be the aim of all agriculturists in the wet tropics to maintain or to reproduce as far as is practicable the conditions which prevail when the land is under forest cover. Tree crops which produce a good canopy of foliage are more suited for cultivation in these areas than are annual crops which require frequent cultivation. Where the nature of the crop does not permit of forest-like conditions being re-created, the use of contour drains, silt-pits, terraces and ground covers is necessary if "run-off" is to be effectively checked.

In effecting control in the use of land so that erosion may be checked it is important to recognise that it is necessary to protect by means of forest reserves or in grassland cover the major catchments and water sheds, provide for the protection of stream banks and steep hill slopes and prevent the destruction of the natural vegetation on the poorer lands.

In the dry tropics, the position differs from that which obtains in the wetter areas. Here the principal activities which are causing injury to land are shifting cultivation, bush firing, increased agricultural activities and in some places overstocking with cattle and goats. The consequences of the exposure of vegetation to these abuses are a general deterioration of environment, soil degradation, a failure

of water supplies and erosion. In many areas in the dry tropics, forest cover is sparse, and in others savannah or grassland prevails. It is only in recent years that grassland problems have been intensively studied in temperate countries and the work has barely begun in the tropics. Data are available which show that "run-off" from grass covered areas is practically nil and that from an erosion point of view they provide efficient cover. In fact it is now recognised that fibrous rooted crop plants are more effective in providing for water absorption than are tap rooted plants and that a good cover of grass will minimize erosion and increase infiltration of water. If, however, these grasslands are, as is so often the case, overstocked with stock concentrations the soil cover is rapidly eaten down or trampled out. Erosion then becomes serious. Similarly, agricultural cultivations in grassland areas can readily become the cause of extensive gully erosion.

The damage which can occur in grass covered country from overstocking or thoughtless agricultural activity can be seen in many parts of East Africa today.

In dry areas also much damage is occasioned by the annual burnings which occur. These cause a definite retrogression in the growth of vegetation and the absorptive capacity of the surface soil is greatly reduced.

Wind erosion is severe in only the driest areas and occurs only when the vegetation has degraded or has been removed for agricultural occupation. The loss of soil structure is one of the main causes responsible for making a soil liable to wind erosion. In areas liable to wind erosion measurable improvements can be effected by strip cultivations and by rough methods of cultivation which attempt the burial of but a portion of the crop residues. It is only when the pressure of population becomes considerable that lands in dry areas liable to wind erosion should be taken up for arable cultivation.

Protection cannot perforce be carried to the extreme as the populations must produce their food for subsistence and some money crops wherewith to secure the cash for the purchase of clothing and other requirements. It is therefore now necessary to consider the measures of control against erosion which have been shown to be effective.

MEASURES OF CONTROL

These vary in accordance with the particular circumstances of the case. They have been devised by man to counteract the troubles which follow upon his thoughtless action in regard to land. It is unnecessary to go into them in any great detail in a paper prepared

for an audience such as that gathered at this Conference. Neither is it necessary to quote figures from the results of experiments designed to ascertain the amount of soil lost under ranging forms of treatment, nor to list the comparative efficiency of the different methods of control. Year by year additional data are being added and from the results secured our knowledge is steadily increasing. The whole essence of the problem is to remember that the measures which require to be adopted in any particular area depend upon the special circumstances of the case. Generalizations are dangerous and each area and each problem must be examined in detail before any particular line of action is advised.

In Kenya, for instance, where attention has in recent years been centred in erosion problems, it is recognised that the chief causes of erosion have been the following:—

1. The deforestation of the hill tops and slopes and sides of river valleys.
2. The depletion of grassland cover by reason of a general increase in cultivation.
3. The cultivation of steep slopes.
4. Gross overstocking in certain areas leading to a destruction of the vegetal cover, and
5. The concentration of stock at and around water supplies, particularly during the dry season.

In any particular area one of these causes may be of more importance than the others, whilst in another area there may be operative a combination of two or more of them. Each cause of erosion demands specific remedies and it is frequently necessary to combine a number together. Progress is often slow by reason of economic and sociological considerations which have to be given most careful thought and consideration.

It has been demonstrated in the United States of America and elsewhere that erosion cannot be effectively checked in areas where the main cause is overstocking unless and until the number of stock is reduced to the normal carrying capacity of the land and it is clear that in many parts of East Africa similar action will have to be contemplated if the people are to be saved from themselves. In the tropics it is not always easy administratively to secure the adoption of this necessary measure of control because of tribal customs, especially in areas liable to serious outbreaks of epizootic diseases and severe droughts, but it is recognised that it is useless to introduce contour banks or spreading works without controlling

the grazing, and that one of the most important measures to demand attention in dry land grazing country is the provision of adequate and satisfactorily spaced water reservoirs or dams for the stock in order that they may be spread over a wider area and excessive concentrations in particular areas reduced. Gradually, as economic considerations become more recognised by the people, improvements will be effected and more satisfactory systems of range management introduced. Economic advantages inevitably lead to the adoption of measures which at first are difficult to secure by reason of the conservatism of the people concerned.

The conditions in the wet tropics are different from those in the drier areas such as those mentioned above as being applicable to Kenya, and the endeavour must there be made to reproduce as far as is practicable the conditions which prevail in the natural conditions of the forest. Successful agricultural undertakings in the wet tropics, if one excepts the rice cultivations under irrigation, have as I have already mentioned been found to be the tree crops of which rubber, tea, cacao, nutmegs and oil palms may be mentioned. These form a satisfactory leafy canopy and where they do not the introduction of shade trees has been beneficial and the establishment of ground covers adopted. The organic litter which is thereby created plays an all-important part in the control of erosion and this supported by such provisions as platform terraces, box terraces, contour hedges, contour drains and silt-pits normally ensure a reasonably stable condition.

It is unnecessary to give constructional details of different forms of terraces and pitted contour drains nor is it necessary to refer to the systems of broad base or narrow contour banks which have been employed successfully in undulating country of medium or low rainfall.

The use of contour hedges or contour strips of mulch has been shown to be effective in several areas and I have seen in parts of Tanganyika and Kenya marked improvements follow upon the adoption of the former and in Uganda the advantages of the latter. The use of contour strips of mulches of elephant grass (*Pennisetum purpureum*) in Uganda has also shown an inexpensive method of inducing the formation of terraces on gentle slopes of friable soils.

Strip cropping is also being employed with success. It can be used on moderate and ungullied slopes whilst contour buffer strips of close growing grasses or cover crops are also effective in certain places.

Recent investigations have also shown that roads, paths and fire breaks must receive attention in connexion with any anti-erosion

measures and that it is of the greatest importance that most careful consideration be given to the natural drainage channels. The use of vegetation as covers in these water outlets is preferable to the construction of engineering works and the whole tendency of modern thought today in regard to anti-erosion measures is to encourage Nature to do her rightful work and to enlist her aid in every manner possible. The aim should be to get away from engineering structures as far as possible and to make the fullest possible use of vegetation. This is the most economical system and produces the most lasting results.

SOIL STRUCTURE

I will now briefly turn to the question of soil structure. Steadily it is becoming recognised that many of our agricultural difficulties have resulted from a loss of soil structure. Sheet erosion, that most insidious form of soil loss, is often unrecognised at the outset. It may not attract attention until finger or other forms of gullies begin to occur. In Uganda, for example, there has been a progressive increase of sheet erosion since the extension of cotton cultivation became general and it is now recognised that, except in a few areas of that country, the soil losses which are being experienced are due mainly to a loss in soil structure.

Soils under forest cover have as a rule a satisfactory soil structure. The decaying roots and the decomposition of the organic leaf-fall are responsible for this, but general conceptions of soils have changed markedly in recent years. From the geological conception we have been introduced to the biological conception. This in turn has been shown to be but part of the whole story and now our thoughts are being directed to the importance of soil crumb, for without a satisfactory soil crumb water absorption is unsatisfactory, biological activities are affected and fertility reduced. In a soil of good structure the mineral particles are cemented together by the colloids into water-stable crumbs, and where the soil crumb has been lost the soil particles become mere dust which may be blown away by the wind or carried down the slopes by every shower. Optimum crumb size varies with different soils and under differing climatic conditions. It may be defined as that which best secures adequate supplies of air and water for plant existence. In wet climates the limiting factor is the air supply whilst in arid climates water is the controlling influence. It follows therefore that in the wet tropics an open soil structure is preferable whilst in the drier tracts a more compact soil structure is desirable. Martin in Uganda is finding that soil structure can be markedly improved in the cotton-growing belt by the use of rotational growths of elephant grass (*Pennisetum purpureum*) between crops of cotton and food crops.

He has in fact found the improvement of soil structure is better under grass, with its masses of fibrous roots, than when green manures are employed. Similar results, although perhaps not quite so spectacular, are being obtained in the drier areas where permanent star grasses (*Cynodon* spp.) are being employed in the place of elephant grass.

This work appears to be of importance and it may lead to a definite form of alternate husbandry, with, say, three-year periods of arable alternated with similar periods when the land is under grass. The system is not very different from that which is now finding favour in England where arable cultivation is being alternated with leys of grasses and clovers for periods of three years upwards.

If the results in Uganda come up to expectations, the change of system is expected to find favour, because it approximates in an organized form to the methods of the shifting cultivations in the grass covered areas.

SOIL FERTILITY

Within certain limitations, a soil owes its character rather to the effects of climate and vegetal cover than to the nature of the parent rocks. Removal of cover and exposure to the sun tends to speed up the chemical processes, while rainfall is responsible especially in the wet tropics for excessive leaching of plant nutrients if the soils are exposed.

In the wet periods, the luxuriance of evergreen vegetation conveys an impression of considerable soil fertility. This has led to the clearing of areas formerly covered with heavy forest for cultivations of both permanent and annual crops. In regard to the latter, many have been the disappointments. Deprived of the products of decay of the forest vegetation the soil has proved to be unproductive and the cleared areas have been abandoned to a useless and often sparse weed growth. Mohr, in his article on "Climate and Soil in the Netherlands Indies" has pointed out that heavy rainfall causes leaching and impoverishment of the soil. Under virgin forest conditions, plant nutrients form a kind of closed cycle, whereby the plant food taken from the soil is returned in the form of plant residues; but when that cycle is broken and crops are taken from the land a loss of fertility begins. This loss of fertility may be excessively rapid under the conditions prevailing in the wet tropics and I have seen excellent forest lands opened for pineapple cultivation reduced to infertile white quartz sands within a period of three years.

Hardy has shown in respect of cacao that the chief nutritive feature of organic matter in cacao cultivation is its content of mineral nutrients and that importance should not be placed on nitrogen to the extent to which it was at one time customary. The results which are being obtained from the use of phosphatic manures in rubber cultivations in the East also tend to support this view.

In the drier tropics, attempts have been made to introduce mixed farming, whereby animal husbandry is introduced into the agricultural system of the small-holder for the purpose of producing supplies of organic manures. In Northern Nigeria progress has been made, but here again except for the value of the organic matter in the building up of soil structure it has been determined that the increases of crop yields have resulted from the phosphatic nutrients of the manure added. Attempts are being made to encourage the spread of mixed farming in many parts of the British Colonial Empire and large numbers of experiments are being carried on. It has yet to be ascertained whether the system can be introduced effectively into the wet tropics where, as has been previously stated, it is now recognised that permanent tree crops are more suited to the prevailing conditions than annual arable cultivations.

Trials are also being made with the use of composts. Their value has been demonstrated in nursery work and in garden cultivations but it is doubtful if the preparation of composts is economically sound for large-scale cultures, especially in areas where the rainfall is adequate to ensure a satisfactory break down naturally of organic waste materials within a reasonable measure of time. In the dry areas, the position may possibly be somewhat different if adequate water supplies are available for the making of good composts. From a soil erosion point of view, however, it must not be overlooked that vegetable wastes and stubbles can be usefully employed as part of anti-erosion measures. I would be very loath to see, as I have done recently in Ceylon, the general adoption of a system of clearing undulating land free of waste vegetable matter for conversion into compost to be transported back to the area from whence it came. This is a most wasteful method and one which is liable to encourage an increase of erosion.

With the use of green manures considerable successes have been achieved in the Netherlands Indies but our experiences in the British colonial dependencies have been variable. In Ceylon and Malaya their use has been advantageous and in Nigeria it has been demonstrated that soil fertility can be maintained at a reasonable level by their use. In East Africa, however, their use has not brought about the results which were expected and except where pigeon pea (*Cajanus cajan*) is being employed for the breaking up of lateritic

hard pans there is a tendency now to await the results of the experimental work designed to test whether the improvements of soil structure which result from land being sown or planted with grass as part of rotation are not of greater value than those which follow upon the employment of green manuring. A strong cultivation of grass or a healthy grass sod produces new roots each growing season to replace the older ones which in their turn add to the soils organic matter. When land is under a grass sod the organic matter in the soil is increased and workers with sugar-cane in Hawaii hold that the amount of roots annually produced by a crop of sugar-cane adequately maintain a soil's organic matter content. I am aware of lands in British Guiana which have been under sugar-cane continuously for nearly 100 years, with only those breaks at intervals of 3-4 years when replanting had to be done. Grassland soils are generally richer in organic matter under comparable conditions than are forest soils and we are, I fear, rather inclined to overlook that the grasslands which are associated with the dry tropics often mean poor soils because of low rainfall and stunted growth of the vegetation rather than an intrinsic harmfulness which has so often been ascribed to the grasses themselves.

CONCLUSION

In conclusion, I would like to say that I have endeavoured to treat this subject of soil conservation, which is attracting world-wide attention, in as comprehensive a manner as time permits. Science in recent years has tended to become departmentalized into a series of narrow specialist channels. Co-ordination is often difficult to secure and a clear picture of the whole impossible to obtain. It is the same with matters concerning soil conservation. There are the enthusiasts for certain particular remedial measures and also those who tend to ride their pet hobby horses. But we must approach the subject from a much wider view-point if sound progress is to be attained.

Much time, energy and money have been expended in many countries on the treatment of gullies which are but the indications of troubles further away at the head of the drainage system. Similarly much time and energy have been expended on the development of terraces, contour bundings and other works in areas where the methods of agriculture are faulty.

One knows full well that circumstances in many tropical countries demand immediate and energetic action if increasing losses from erosion are to be checked and ultimate economic ruination prevented. Sound planning of land usage is essential but without

sound methods of agricultural husbandry and range and woodland management attempts to check erosion will be of but temporary value. Soil conservation in its truest sense will not be achieved unless it is tackled in the widest possible way. The building up of deteriorated soils is a relatively slow process for soil building can only be effected if an increase in the organic matter is secured. If this can be accomplished other effects, physical and chemical, will follow.

The present position demands firstly that the rot which is at present occurring in many areas should be stopped and that at the same time strenuous attempts be made to build up sound agricultural practices The marriage of animal husbandry with crop production must be achieved in all areas where the conditions are suitable and where they are not, crop production must proceed along lines which conform with the dictates of Nature.

In the Netherlands Indies, the planned utilization of land has long been the basic policy of the Government and it has long been recognised that agricultural practices should conform to the needs of the land.

It should be our endeavour to foster in every way possible and in the widest circles this thought for the land. Erosion can be controlled if Nature is carefully studied and her secrets ascertained. The land is the chief asset of the tropical peoples and the proper use of that asset by present generations combined with its conservation for those to follow should be the primary aim of all.

Exploitation of soil fertility has gone far enough in many areas, whilst in others it has gone too far. A full stock of the position is now being undertaken and it is to be hoped that all who can will add their quota to the endeavour necessary to improve matters.

SHOT-HOLE BORER

In the report of the discussion on Shot-hole borer which took place at the Institute's Sub-Conference, *vide Tea Quarterly* 1940, Vol. XIII, Part I, pp. 28-34, certain yield figures from an infected estate were quoted by Mr. King. These figures were kindly supplied by Mr. Grant Cook, being data obtained from a field on Sarnia Estate. Mr. Grant Cook wishes to stress the fact, which he explained during the discussion but which does not appear in the report, that while the loss of crop may not seem very severe, the present cropping level has only been maintained by the application of an additional dose of manure, *i.e.*, by doubling the cost of normal manuring, a practice which, he suggests, might not be an economic proposition on many estates as a measure against shot-hole borer. It was for this reason he stressed the importance of biological control.

EDITOR.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 12-4-40

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held in the Ceylon Chamber of Commerce Rooms, Colombo on Friday, April 12th, 1940, at 2-30 p.m.

Present.—Messrs. James Forbes (Chairman), the Financial Secretary (Hon. Mr. H. J. Huxham), the Director of Agriculture (Mr. E. Rodrigo), the Chairman, Planters' Association of Ceylon (Mr. R. C. Scott), the Chairman, Ceylon Estates Proprietary Association (Mr. C. H. Bois), Messrs. J. W. Oldfield, C.M.G., O.B.E., M.C., J. C. Kelly, S. F. H. Perera, R. Gregor, W. H. Gourlay, and Dr. R. V. Norris (Director and Secretary).

Letters expressing inability to attend were received from Messrs. R. G. Coombe and T. B. Panabokke.

1. The notice convening the meeting was read.

2. The Minutes of the Meeting of the Board held on the 14th December, 1939, were confirmed.

3. MEMBERSHIP OF THE BOARD AND COMMITTEES

(i). *Board.*—Reported that Mr. T. B. Panabokke had been nominated by His Excellency the Governor as a member of the Board for a further period of three years as from 2nd February, 1940, and that Mr. W. H. Gourlay had been appointed by the Ceylon Estates Proprietary Association to act for Mr. I. L. Cameron during the absence of the latter on leave, with effect from 2nd February, 1940.

The Chairman welcomed Mr. Gourlay.

(ii). *Estate and Experimental Sub-Committee.*—Approved that Mr. F. A. Bond and Mr. W. J. Craig be invited to act on the above Committee during the absence on leave of Messrs. D. T. Richards and J. T. Young.

4. FINANCE

(i). *Audited Accounts for 1939.*—The Chairman said the Auditors' Reports on the Accounts for 1939 had been considered by the Finance Committee who considered them to be highly satisfactory. From the summary of Receipts and Expenditure for 1939 tabled, it would be seen that the surplus on revenue account, amounting to Rs. 45,640 was Rs. 13,638 higher than anticipated in the revised estimates while liquid assets were up by Rs. 17,649.

Equally satisfactory reports had been received on the accounts of the Junior Staff Medical Fund and Junior Staff Provident Fund. A feature of the Provident Fund was the wide use made of this for endowment insurances. The Medical Fund had also proved of great benefit to members, a sum of Rs. 1,397 having been paid out during the year on account of medical expenses incurred by members.

The audited accounts were unanimously approved on the proposition of Mr. J. C. Kelly seconded by Mr. W. H. Gourlay.

(ii). *Institute's Accounts to 29th February, 1940.*—The Chairman said the question of the existing cash balance had been considered by the Finance Committee. In view of the present international situation, it was considered inopportune to invest further funds at the moment but the Committee thought the balance of instalments towards the next loan payment should be placed on fixed deposit. These would amount to about Rs. 37,000. This was approved and there being no further comment, the accounts to the 29th February were accepted on the proposition of Major Oldfield seconded by Mr. R. C. Scott.

(iii). *Additional Expenditure, 1940.*—The following additions to the estimate were approved:—

ESTATE CAPITAL ACCOUNT

(a). *Midwife's Quarters and Maternity Room.* Additional vote of Rs. 2,850.—The Chairman explained that the original intention had been to complete the work, total cost of which was estimated at Rs. 4,850, in two stages and Rs. 2,000 had been included in the original estimate for 1940. The Estate and Experimental Sub-Committee had recommended that the complete scheme be proceeded with now and the building constructed in accordance with the plan approved by the Director of Medical and Sanitary Services which was tabled. The Finance Committee concurred.

(b). *Internal Cart Road* Rs. 1,000.—The Chairman explained that this was for the consolidation and extension of the new internal road. The Visiting Agent was anxious to accelerate completion of this work to render possible the use of a small leaf lorry.

(c). *Machinery.*—Fermenting Table Rs. 75.

RESEARCH CAPITAL ACCOUNT

Mechanic's Quarters Rs. 2,000.—This sum had previously been voted in 1939, but at that time it was possible to make other temporary arrangements which were no longer available.

ESTATE REVENUE ACCOUNT

(a). Vote 10, Pensions. Increased Rs. 100.

(b). Vote 25, Crèche Coolies. Rs. 368.

(c). Vote 63, Machinery. Rs. 420 for replacement of factory chimney.

(d). Temporary War Bonus. At the rate of Re. 1, cents 75 and cents 50 per mensem for men, women and working children, as approved by the Planters' Association of Ceylon and the Ceylon Estates Proprietary Association, payable as from 1st March. Should this continue for the rest of the year, the cost would be about Rs. 2,775 or cents $1\frac{1}{2}$ per lb.

5. ST. COOMBS ESTATE

(a). The Chairman invited comments on the Visiting Agent's reports dated 4th December, 1939, and 10th February, 1940. Both these reports had been considered by the Estate and Experimental

Sub-Committee at their Meeting held on the 17th February, the Minutes of which had been issued to the Board.

The Chairman also gave details of the working results for 1939, viz:—

Final cost of production was 55.69 cents per lb. on a crop of 151,929 lbs. The average selling price was 84.74 cents per lb. gross and 79.74 nett. The profit on estate working account was Rs. 36,399. 38,553 lbs. of tea had been supplied to Government on the short term contract.

For 1940, 70 per cent of the crop had been accepted by Government at a price of 83.55 cents per lb. This would leave about 55,500 lbs. available for the local market.

In reply to Mr. Bois, the Director said full payment had been received for the invoices sent to London in the latter part of 1939.

The Visiting Agent's reports were recorded.

(b). *Food Production.*—Reported that in the small scale trials, bulrush millet alone had given satisfactory results. Owing to the drought it had not been possible as yet to plant up the 2-acre block in which sweet potato and Rangoon beans were to be tried.

6. SENIOR SCIENTIFIC STAFF

(i). Reported that Dr. T. E. T. Bond had arrived in Ceylon on the 8th February. The appropriate agreement had been signed by the Secretary, Ceylon Association in London, on behalf of the Board.

LEAVE ARRANGEMENTS

(a). *Leave Dates.*—The Chairman said the Director should have proceeded on leave early in February but owing to the war this had been held up. Dr. Eden was due for leave early in 1941 followed by Dr. Gadd later that year. Congestion would result if leave were unduly postponed and he asked the Board to decide what their policy should be.

It was decided that officers should take leave as and when due. The Board also approved that Dr. Gadd should act as Director during Dr. Norris' absence.

(b). Reported that a Tea Conference was likely to be held shortly at the South Indian Research Station. In the Director's opinion it would be advantageous for Dr. Eden to attend this.

This was approved.

7. APPLICATION FOR GRANT FROM THE COLONIAL DEVELOPMENT FUND FOR "PHLOEM NECROSIS" WORK

The Chairman said the Institute's application had been supported by the Minister for Agriculture and Lands and passed on to the Financial Secretary for further action.

In reply to the Chairman, the Financial Secretary said the application had been forwarded to London.

8. ANY OTHER BUSINESS

(i). Mr. Perera asked if it would be feasible to plant up an area of the unopened land on St. Coombs with tea seed bearers. The Director expressed the view that this would be premature at the moment. Selection was proceeding but he did not think bearers should be planted up until material was available which had been definitely proved to be superior to existing supplies.

In reply to Major Oldfield, the Director said a good many estates were interesting themselves on selection work and the Institute was anxious to keep in close touch with them.

(ii). *Tasting of Experimental Teas.*—The Director said the Institute had been greatly helped by the assistance given by Colombo tasters in connection with the experimental work on manufacture. In particular he referred to Messrs. R. H. Horne, J. M. Westwood, M. P. Saunders, H. W. T. Sherwood, and A. Pelly Fry, who at much inconvenience and trouble to themselves had examined and reported on a very large number of experimental samples.

The Board recorded a very cordial vote of thanks to these gentlemen for their services.

The Meeting then concluded with a vote of thanks to the Chair.

ROLAND V. NORRIS,
Secretary.

NOTICES.

The Institute's Laboratories and Offices are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. M. Y. Hemachandra & Co., Forwarding Agents. *Carriage should be pre-paid.*

Visitors' Days.—The *second* and *last* Wednesdays in each month have now been set aside as Visitors' Days at St. Coombs Estate and also at the T. R. I. Sub-Station, Gonakelle Estate, Passara, when it is hoped anyone interested will visit the Stations.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

RULES FOR THE OCCUPATION OF ST. COOMBS GUEST HOUSE

(1). The Guest House is normally intended for the use of persons visiting the Institute and St. Coombs Estate on business. Children can in no circumstances be accommodated.

(2). Permission to occupy a room for the night must be obtained from the Director in writing and, unless sufficient notice be given, accommodation cannot be guaranteed. Two double rooms are available for the use of visitors accompanied by their wives.

(3). All visitors must sign the Visitors' Book on arrival.

(4). A bedroom may not be occupied for more than one night if required by another visitor. This shall not apply to Members of the Board or of Committees meeting at St. Coombs who shall also be entitled to priority in the allocation of accommodation when on official business.

(5). Complaints or suggestions shall be entered in the book provided for the purpose and not made to the Guest House Staff.

(6). All payments due for services rendered shall be made in *cash* to the steward-in-charge and a receipt obtained from him on the official form. The scale of approved charges is posted in the building. The steward is forbidden to give credit or to accept cheques.

(7). Liquor is supplied for consumption *in the premises only.*

(8) The Institute accepts no responsibility for cash, jewellery or other valuables of any kind left in the Guest House.

(9). All breakages will be charged for at cost price.

ROLAND V. NORRIS.
Director.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon:—

(1) Mr. R. G. Coombe.

(2) Mr. Jas. Forbes, (Chairman)

(3) Mr. J. D. Hoare (on leave) Mr. R. Gregor (acting)

(B) Representing the Ceylon Estates Proprietary Association:—

(4) Major J. W. Oldfield, C.M.G., O.B.E., M.C.

(5) Mr. I. L. Cameron (on leave) Mr. W. H. Gourlay (acting)

(6) Mr. J. C. Kelly

(C) Representing the Low-Country Products' Association:—

(7) Mr. S. F. H. Perera

(D) Representing the Small-Holders:—

(8) Mr. T. B. Panabokke, Adigar

(E) Ex-Officio Members:—

(9) The Hon. the Financial Secretary

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

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The publications of the Tea Research Institute will be sent, free of charge, to Superintendents of Ceylon tea estates, over 10 acres in extent, and to Estate Agencies dealing with Ceylon tea, if they register their names and addresses with *the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle.*

Other persons can obtain the publications of the Institute on application to the Director, the subscription being Rupees fifteen per annum for persons resident in Ceylon or India, and £1-5-0 for those resident elsewhere. Single numbers of *The Tea Quarterly* can be obtained for Rs. 2-50 or 4*s*. In the case of Indian cheques four annas should be added to cover commission.